

(MU) were delivered at each angle: The reference dose without couch attenuation is the average dose at 0°, 90° and 270°. Gantry angles ranging from 235° to 223° in 1° increments are used to measure the edge attenuated dose. And gantry angles ranging from 220° to 180° in 10° increments to measure the dose attenuation of the central region of the couch.

Skin dose was measured with radiochromic films and FilmQA Pro. Several films were placed between RW3 slabs in different depths. The center of RW3 phantom coincides with linac isocenter.

First, films were located at the surface, 0.5cm and 1.5cm from the surface, and in the center of the RW3 phantom. Then 200MU were delivered with an open 10x10 field and with zero gantry angle. The irradiated films were removed and other films were placed under the phantom, 0.5cm and 1.5cm from the couch and in the center. The opposite beam was delivered, so we measure the effect of the couch to the dose distribution in the buildup region.

Results: Table 1A Comparison results between measured and calculated relative transmitted dose (T%), with and without the couch. Table 1B Evaluation of skin dose increment and comparison results between scanned and calculated increment of skin dose.

Increment of skin dose.								
TABLE 1A	Monaco						Measurements	
	Without table			With table				
Angle	cGy	T(%)	diff %	cGy	T(%)	diff %	nC	T(%)
0	69	1	0.1	68.1	1.001		2.35	0.999
90	68.7	0.996	-0.4	68.1	1.001	0.2	2.35	0.999
270	69.3	1.004	0.3	67.8	0.997	-0.4	2.35	1.002
235	69	1	4.8	65.7	0.966	1.3	2.24	0.954
234	69	1	5.6	64	0.941	-0.6	2.23	0.947
233	69	1	4.2	65	0.956	-0.4	2.26	0.96
232	69	1	3.1	66.9	0.984	1.4	2.28	0.97
231	69	1	3.1	66.8	0.982	1.3	2.28	0.97
230	69	1	3.5	66.5	0.978	1.3	2.27	0.966
229	69	1	3.5	66.3	0.975	1	2.27	0.966
228	69	1	3.7	66.1	0.972	0.8	2.27	0.965
227	69	1	3.6	65.8	0.968	0.3	2.27	0.965
226	69	1	3.7	65.4	0.962	-0.2	2.27	0.964
225	69	1	3.9	65.2	0.959	-0.4	2.26	0.962
224	69	1	4.1	65.2	0.959	-0.2	2.26	0.961
223	69	1	4.4	65.4	0.962	0.4	2.25	0.958
220	69	1	5.4	65.4	0.962	1.4	2.23	0.948
210	69	1	3.7	65.9	0.969	0.5	2.27	0.964
200	69	1	3.2	66	0.971	0.2	2.28	0.969
190	69	1	2.9	66.1	0.972	0	2.28	0.972
180	69	1	2.9	66.4	0.976	0.4	2.29	0.972
average difference %			3.3	average difference %			0.4	

TABLE 1B	Monaco		Radiochromics	
AP 10x10 SSD=91cm, 200MU without couch	Dose (cGy)	percentage of Dmax	Dose (cGy)	percentage of Dmax
Over 18cm of RW3 (at the surface)	56.5	23.7	49.8	20.9
0.5cm from the surface	213	89	205	86
1.5cm from the surface	239	100	238	100
Iso, at 9cm depth	174	73	166	69.8
PA 10x10 SSD=91cm, 200MU with couch	Dose (cGy)	percentage of Dmax	Dose (cGy)	percentage of Dmax
under the phantom, 18cm of RW3	228	93.8	221	92
0.5cm from the couch	241	99.4	239	99.5
1.5cm from the couch	243	100	240	100
Iso, at 9cm of depth	158	65	163	67.7
Increment of skin dose	3.96		4.4	

Conclusion: The couch model improves the discrepancy between measured and computed attenuated dose. If we take into account the couch in treatment planning calculations, this average difference decreases from 3.3% to 0.4%. The couch increases 4 times the skin dose and the couch model provides an accurate calculated dose in the buildup region.

#### PO-0825

Characterization of a commercial EPID 3d software for in vivo dosimetry.

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Purpose or Objective: Dosimetry Check (DC) is a commercial software that allows reconstruction of 3d dose distributions

using transit and through-air EPID images. DC is composite of two parts: a deconvolution kernel that converts EPID images to fluence, and a pencil beam algorithm to calculate the dose. It can be used for pre treatment QA verification and for in vivo dosimetry. In this work we evaluated the suitability of DC software for in vivo dosimetry of VMAT treatments.

Material and Methods: DC (v4.10) was used along with Elekta Synergy® Linac (6 and 10 MV beams) equipped with a-Si Electronic Portal Imaging Device (EPID) Iview-GT. Twenty VMAT (5 prostate, 5 whole pelvis, 5 lung, 5 head and neck), elaborated by treatment planning system (TPS) Elekta Monaco® 5.0 were measured. Through-air (EPID T-A) and transit EPID images were used for three dimensional dose maps reconstruction in homogeneous phantoms. Octavius 4D with 729 2D array was used as reference. Gamma analysis at 3% local dose /3mm DTA was performed. Doses from through-air measurements were also reconstructed in the planning CT (T-A in plan TC) and compared with the treatment planning dose maps. Gamma pass rate of DC dose maps were compared with those of 729 in the Octavius 4D.

#### Results:

Anatomical Site	Energy	Octavius 4d	EPID T-A	EPID Transit	T-A in plan TC
Prostate1	X10	97.7	92.6	92.5	92.9
Prostate2	X10	95.4	83.3	87.1	81.3
Prostate3	X10	96	91.8	92.5	94.8
Prostate4	X10	96	90.5	89.9	90.2
Prostate5	X10	98.8	94.8	95.4	95.9
Whole Pelvis1	X10	92.5	94.4	95.9	94.5
Whole Pelvis2	X10	88.9	95.2	85.9	93.5
Whole Pelvis3	X10	88.9	91.8	83.6	91.8
Whole Pelvis4	X10	88.1	90.2	84.6	86.3
Whole Pelvis5	X10	89.3	95.5	92.34	95.6
Lung1	X6	97.7	92.0	96.8	89.2
Lung2	X6	98.0	96.8	97.8	85.8
Lung3	X6	96.0	97.5	99.4	79
Lung4	X6	97.2	93.4	98.7	72.8
Lung5	X6	97.0	96.8	97.4	96.3
Head and Neck1	X6	90.3	81.9	72.4	89.7
Head and Neck2	X6	91.2	70.1	73.8	90.6
Head and Neck3	X6	92.9	75.9	73.4	90.7
Head and Neck4	X6	92.5	80.1	83.3	94.5
Head and Neck5	X6	92.6	79.5	86.4	89.8

Table1 Gamma pass rate. EPID T-A are computed in the synthetic Octavius 4D phantom, EPID transit is measured and computed in the homogeneous Octavius II phantom.

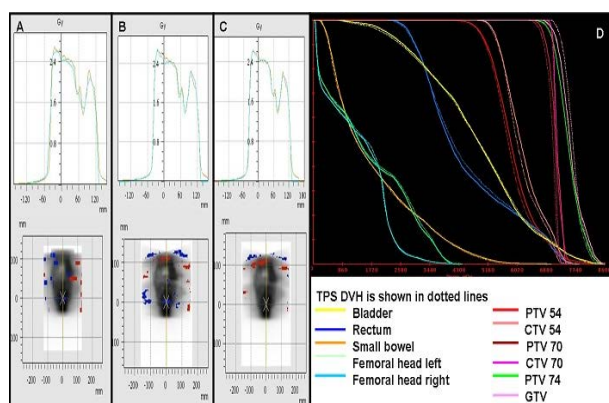


Figure1: Results of a whole pelvis SIB treatment. In the upper part comparison of profiles for Octavius 4D (A), T-A EPID (B) and Transit EPID (C). In yellow the TPS profile. The lower part of the image contains central coronal map of gamma > 1 points. In D the comparison of DVH measured by DC in plan CT (solid) versus TPS (dotted lines) is shown.

Gamma pass rates are shown in the table1. The assessment of VMAT plans shows a mean of 93.9% points with gamma < 1 for Octavius 4d (3.5% SD), 89.2% and 7.9% SD for EPID T-A, 89% and 8.5% SD for EPID Transit and 89.8% and 6.1% SD for T-A in plan CT. Transit and through-air EPID acquisitions produced similar gamma pass rates. Through-air EPID images computed by DC in the planning CT showed gamma pass rate in agreement with those of Octavius 4d in the prostate, whole

pelvis and head and neck, in lung instead, gamma pass rates were lower in 4/5 cases.

**Conclusion:** DC is a suitable tool for VMAT in vivo dosimetry. The pencil beam algorithm can be inaccurate in the presence of low-density inhomogeneities.

#### PO-0826

**Benchmarking computed IDD curves for four proton treatment planning systems against measured data**

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**Purpose or Objective:** Accurate beam modelling is an essential function of a treatment planning system (TPS) to ensure that plans can be calculated that are deliverable within clinically acceptable tolerances. The purpose of this work is to evaluate the computed integral depth dose (IDD) curves of four commercially available proton TPSs, benchmarked against measured data. The four TPSs (EclipseTM, XiO®, Pinnacle3, RayStation®) were commissioned using pencil beam scanning data from the University of Pennsylvania (UPenn) facility.

**Material and Methods:** A water cube phantom (40cm<sup>3</sup>) was created in each TPS for calculation of IDD curves. Calculation grid size set to 1mm in all TPSs. Individual IDDs for 27 nominal energies, ranging from 100 to 226.7MeV, were calculated by integrating the calculated depth dose distributions. These were all benchmarked against measured data from UPenn, comparing the clinical range at 80% distal dose (D80), Bragg peak width between distal and proximal 80% (D80-P80), range at 0.5% (R0.5), and distal penumbra between D80 and R0.5. Gamma-index analysis with pass criteria of 1mm/1% was also used to compare computed and measured IDDs.

**Results:** Mean percentage of IDDs with >95% pass rate for 1mm/1% criteria were 96.7% (SD 4.9) for XiO®, 94.1% (SD 8.9) for EclipseTM, 95.4% (SD 8.6) for RayStation®, and 49.2 (SD 26.0) for Pinnacle3. Maximum differences between computed and measured IDD data are shown below. No correlation with nominal energy was observed.

	Maximum differences [mm]			
	Range 80% (D80)	Peak width (D80-P80)	Distal penumbra (D80-R0.5)	Range 0.5% (R0.5)
XiO®	0.1	0.1	0.2	0.2
Eclipse™	0.8	0.6	1.1	1.2
RayStation®	0.3	0.4	0.8	0.8
Pinnacle3	0.4	0.6	0.9	1.3

**Conclusion:** Characteristics of computed IDDs were compared to measured data for four commercially available TPSs. All were within clinically acceptable tolerances, with XiO showing the closest agreement. Differences observed were attributed to TPS specific beam modelling. Further investigation will assess the cumulative impact of these discrepancies on verified clinical treatment plans.

#### PO-0827

**Principal component analysis for deviation detection in 3D in vivo EPID dosimetry**

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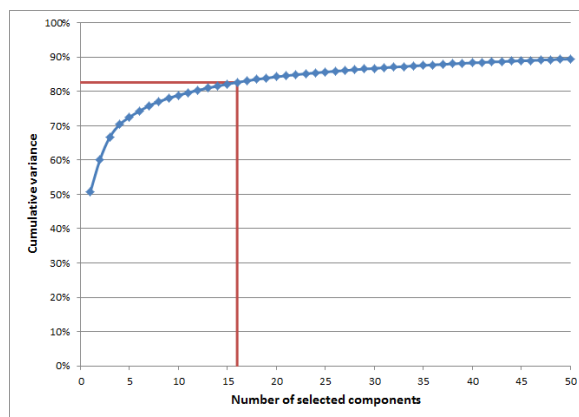
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**Purpose or Objective:** One of the clinical issues our institute faces regarding in vivo EPID dosimetry is the number of raised alerts. For example, alerts are raised for 49% of the treatments in case of head-and-neck (H&N) VMAT treatments; an alert is raised when dosimetry results are

found deviating according to statistics derived from the histogram of 3D  $\gamma$ -analysis results. These alerts are mostly found to be patient-related or attributable to limitations of our back-projection and dose calculation algorithm. After inspection, an intervention is considered for only 0.3% of the treatments. The purpose of this study is to develop a principal component analysis (PCA) based classification method to improve the specificity of our EPID dosimetry system. In particular, in contrast to our current classification method, PCA allows for the spatial distribution of  $\gamma$ -values to be taken into account for deviation detection.

**Material and Methods:** The input for PCA consisted of 3D  $\gamma$ -distributions (3%/3mm), one per treatment arc per fraction. In total, 2024 3D  $\gamma$ -distributions from 499 H&N VMAT treatment-plans were included. As an initial choice, components describing at least 1% of the variance were selected. The distribution of variances over the components was inspected to validate this choice. Using these components, new 3D  $\gamma$ -distributions were created by projecting each input 3D  $\gamma$ -distribution on only these components and then projecting the result to the original coordinate system of the 3D  $\gamma$ -distributions. If the selected components describe the original  $\gamma$ -distribution well, the new and original  $\gamma$ -distributions will be similar. This similarity was quantified by the root mean square (RMS) d of the difference between the two  $\gamma$ -distributions; a  $\gamma$ -distribution was marked as deviating when d exceeded a threshold. All true positive  $\gamma$ -distributions (n = 2) in the dataset, as identified by experienced medical physicists, were used to determine this threshold for identification of alerts.

**Results:** The first 16 components were each found to describe at least 1% of the variance; cumulatively, they account for 83% of the variance in the dataset. Figure 1 shows the cumulative variance accounted for as a function of selected components and indicates that the choice for selecting components is reasonable. After finding and applying the appropriate threshold for detecting the identified true positives, a drop in alert rate from 49% to of 11% was observed, corresponding to an increase in specificity from 0.51 to 0.89.



**Conclusion:** The PCA-based classification method presented in this study enhances the specificity of deviation detection in 3D in vivo EPID dosimetry of H&N VMAT from 0.51 to 0.89, compared to our current clinical  $\gamma$ -histogram based method. Before clinical implementation, a rigorous validation is required.

#### PO-0828

**Dosimetric assessment of a second generation Multi-Leaf Collimator for robotic radiotherapy**

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